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CONTENTS

Tuberculosis of the Kidneys from the Roentgen Standpoint..... 83
E. W. ROWE, M. D., Lincoln, Nebr.

The Modern Treatment of Cancer of the Uterus with the Combined Surgical and Radiological Methods..... 90
HENRY SCHMITZ, A. M., M. D., F. A. C. S., Chicago, Ill.

Physical Factors Underlying the Use of Radium and Radium Emanation 107

Radiumtherapy of Thyroid.....121
A. N. CLAGETT, M. D., Chicago, Ill.

The Elementary Physical Chemistry of the Development of *X*-Ray Films and Plates.....125

Organization 135

Abstracts 137

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TUBERCULOSIS OF THE KIDNEYS FROM THE ROENTGEN STANDPOINT*

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I. Introduction
II. Roentgenography compared with other methods
III. History and autopsy reports
IV. Pathology
V. Clinical history and physical findings
VI. The roentgen method of diagnosis, with description of findings.
VII. Differential diagnosis
VIII. Conclusions

I. The purpose of this paper is to call attention to the value of the roentgen examination of the kidneys and ureters in the diagnosis of tuberculosis affecting the urinary tract. In looking over the literature it has been found, with one or two exceptions, that the method has not received general adoption as one from which deductions are safe and accurate. As our knowledge of each disease increases, we find through experience in plate interpretation and adapted technique an increasing safety in the roentgen diagnosis.

This paper is not meant to be a statistical study of cases. That will be left to workers where clinical material is more abundant. But I wish to call attention to the fact that the roentgen findings in renal tuberculosis are far more definite and positive than is generally understood. Even the unaided diagnoses outrun some of those pathological conditions in which the use is already standardized and accepted.

II. Roentgenography of tuberculous kidney should not be used as a short cut to diagnosis. It is but an addition

*Read before the Omaha Roentgen Society, March, 1920.

to the already heavily loaded armamentarium. But, however expensive in time or money, it gives increased accuracy to final deduction. The present-day conception of renal tuberculosis has passed through different stages. These may be marked by the following list of steps in every complete examination:

The old and time-honored methods

1. The clinical history
2. Physical examination

New method, scarcely twenty-five years old

3. Cystoscopy
4. Urethral catheterization
5. Roentgen examination
   a. Direct
   b. Indirect

Not one of these steps, once introduced, has been discarded. They make up the routine for every complete examination. Nothing should be omitted, but often the roentgenogram alone of a suspected kidney will contain definite and positive evidence of tuberculosis.

III. The modern conception of tuberculous kidney dates back scarcely more than twenty years. The first recorded case goes back to Morgagni in 1767. This was an uncommon type, even today: a kidney made tuberculous by contiguous tuberculous lymph glands. It was early thought that tuberculosis in the kidney was the end stage of tuberculosis in the urinary tract. Later it was discovered that one kidney alone was involved in one-half of the cases. After this, surgery of the kidney made rapid progress. Just before 1900 modern cystoscopy and catheterization were born. These methods quickly showed that tuberculosis was often unilateral and demonstrated which kidney was involved.

From the study of histopathology and autopsy reports the interpreter of plates must obtain the large part of that knowledge which aids him in a diagnosis. Compiled autopsies give some interesting facts.

Without reference to the particular class of subjects, 19,688 autopsies give 603 tuberculous kidneys, a per cent of 4.7. Another list of 6,000 autopsies gives 5.6 per cent. In cases with active tuberculosis elsewhere in the body, the number climbed to 20.2 per cent. When miliary tuberculosis was present, practically all the cases showed tuberculous kidneys.

The relative frequency of miliary and caseo-cavernous forms is as two to one. In autopsies of children the percentage of tuberculous kidneys runs to 15 per cent. The proportion of unilateral to bilateral caseo-cavernous tuberculous kidney must be explained to be understood. Of 459 cases reported as tuberculosis of this type, 55.1 per cent were unilateral. These autopsies represent extreme cases that died. The earlier in the involvement, the more likelihood there is of a unilateral tuberculosis. Clinically, the proportion of unilateral involvement runs to 90 per cent or above. (Bevan, Albarron, Kronlein, Israel.) In children, involvement of both kidneys is more likely. When both kidneys are involved, it is rare that both are involved in the same degree. In cases of bladder tuberculosis without a demonstrable tuberculous lesion outside the urinary tract, one hundred per cent had tuberculous kidney. Active tuberculosis in the lungs means a greater probability that both kidneys are involved.

Autopsies showing primary tuberculosis in the kidney without evidence of tuberculosis elsewhere in the body are rare. Clinically the ratio is as high as 60 or 70 per cent.

IV. There are three gross tuberculous lesions of the kidney:

1. Miliary tuberculosis
2. Tuberculous infarction
3. Tuberculous nephritis

Miliary tuberculosis does not concern the roentgenologist. It is acute and ends in death. Tuberculous infarction is very rare, and for practical purposes may be forgotten.

Tuberculous nephritis is the important form, and with its caseous areas, cavernous pockets, inspissated pus and calcium deposits, gives the most positive shadows upon the roentgenogram. It may be the only serious lesion in the body. Mallory gives the following concise statement of the histopathology: "It is due to the tubercle bacilli gaining entrance to the pelvis of the kidney and causing a pyelitis. From here they infect the tubules and the intervening lymph vessels and tend to spread toward the cortex, causing necrosis and ulceration which start usually at the apices of the pyramids and gradually erode them. The lesion is analogous to tuberculosis extending along the bronchi of the lung. The process may result in the formation of numerous abscess cavities, some of which may reach the capsule of the kidney; or the whole kidney may be transformed into a sacculated cavity filled with cheesy or putty-like material."

Renal tuberculosis is rarely acquired by adjoining structure, and only occasionally by extension upward in the urinary tract from a tuberculous infection lower. It is nearly always a direct extension from a lesion of hematogenous origin in the pelvis, or by bacilli being carried along a tubule from a lesion in the cortex.

V. The clinical history is often obscure. Some kidneys heal after a complete destruction and closure of the ureter. They may be discovered by accident or in a search for some vague group of symptoms. Nevertheless the typical course is chronic and is characterized by —

1. Systemic manifestations — loss in weight, or septic temperature. About 30 per cent of the patients will present themselves in robust health, 40 per cent in fair health, and the balance in poor health.

2. The earliest and most persistent complaint arises from bladder disturbance. In 70 per cent they are the initial symptoms; in 90 per cent they are alone or in combination with others.

3. Pain is uncertain and charcteristic in only 10 per cent.

The back and lumbar region are the seat. Palpation, if made, may demonstrate a tender mass. A tumor is never the presenting symptom.

4. The urine changes vary — sometimes turbid, sometimes clear. Hematuria with a 25 per cent incidence is usually small in amount, though brisk hemorrhage may occur.

VI. Roentgen evidence of a tuberculous kidney may be divided into (a) Indirect; or (b) Direct.

The indirect method depends upon the use of the cystoscope, ureteral catheters, and the use of opaque media. It is not the purpose of this paper to give a description of pyellography. It is in an advanced stage of development. But the roentgenologist must be in touch with its value in the diagnosis. The following points summarize its chief value and may be classified as indirect roentgen evidence:

1. Abnormalities, such as one kidney, or several ureters.
2. Stricture or dilatation of the ureter.
3. The determination of the presence or health of the opposite kidney.

The cystoscope adds the following valuable information when it can be employed:

1. The presence or absence of bladder involvement.
2. The condition of the ureteral orifice. In 50 per cent of the cases the orifice on the affected side will be typically inflamed.
3. A determination of the function of both kidneys.

In our clinic we are now using a 32 per cent solution of sodium bromide for the opaque media. We found that it gives a clearer outline, is non-irritant and completely absorbed in a few hours. Besides, it is cheap and easily sterilized by boiling.

The injected media shows the relation of suspected shadow to the kidney and outlines the injured kidney or dilated ureter in a typical manner. Inflammatory dilatation of the pelvis when caused by tuberculosis is larger and more irregular and confined to the calyces. When the cortex becomes the seat of necrosis the pelvic outline may

disappear in the part affected, or completely. The media will then show indistinctly and disappearing into the parenchyma. Irregular forms appear, or the entire kidney may be sac-like.

The renal outline itself is of little value in showing size or pathologic contour. The possibility of error is too great.

The roentgenographic shadows of tuberculous deposits are due to the presence of calcium. They assume various forms, from scattered foci to complete calcification as found in the putty-kidney. They are less dense than stones and the outlines are not sharp, but grade off into the surrounding tissue. They may appear as elongated, isolated streaks, or as multiple, sharply defined areas in one pole or the other. The size of the shadow in no way indicates the extent of the tuberculous process. Large caseated kidneys may cast no shadows. On the other hand, enough calcium may be at hand to give a complete cast of the kidney.

Braasch gives accurate statistics showing that not only do one in five of their cases operated upon for tuberculosis of the kidney give roentgen findings, but that 70 per cent of these are positive and typical. This is a step further than any other writer has gone on record. The number of kidney shadows recognizable is largely a personal equation. But the fact remains that study and experience make it possible to recognize a higher percentage than in the past. Histopathology gives different form and density to the resulting shadows. The result will depend largely upon the individual ability of the observer to translate into roentgen terms the histopathology.

VII. From our present knowledge it is obvious that the differential diagnosis cannot always be made. Careful checking of corroborating evidence should make it fairly safe to rule out (1) gallstones, (2) mesenteric, and (3) glandular areas of calcification. The location, and the concentric layers of deposited calcium or faceted surfaces, should distinguish them. (4) Renal stones are more dense, often brilliant, usually sharply outlined, and rarely in the

opposite kidney. Here, not infrequently, the differentiation cannot be made.

CONCLUSIONS

1. The interpretation of tuberculous shadows in roentgenograms of the kidneys becomes more definite and more accurate, as in all other parts of the body, the more often they are seen.
2. The direct method should be employed in all suspected cases of renal tuberculosis.
3. The indirect method should be employed in all cases of doubtful infection, and those in which direct interpretation needs corroboration.
4. The roentgen method should be the routine in all cases of examination of the urinary tract.
5. A roentgen examination of the lungs should be made in every case of renal tuberculosis. If no active tuberculosis is found in the lungs, the chances are very great that the involvement is unilateral and therefore operable.

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THE MODERN TREATMENT OF CANCER OF THE UTERUS WITH THE COMBINED SURGICAL AND RADIOLOGICAL METHODS

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The treatment of cancer must be based on a painstaking physical examination. The findings obtained will enable us to determine: 1, whether the growth is localized in the invaded organ or region of the body; 2, whether it has extended into the neighboring organs and tissues; 3, whether it has invaded the regional lymphnodes; 4, whether secondary cancers have occurred in distant organs or tissues, and 5, whether other organic and constitutional diseases, such as uncompensated heart disease, chronic Bright's Disease, pulmonary tuberculosis, diabetes mellitus, and so forth, coexist. Should the malignant disease be clearly localized it is curable. A complete surgical eradication will suffice to totally remove or destroy all of the abnormal cell elements. Therefore, if patients afflicted with cancer disease would apply for treatment to the surgeon during the localized or incipient stage of the disease, the question of how to permanently cure cancer would be a very simple one to answer.

However, clinical experience teaches that a radical cure of cancer is a difficult matter. For instance, abdominal radical panhysterectomies for carcinoma of the uterus are followed by recurrences in about sixty per cent during the first year and in an additional fifteen per cent during the second year following the operation. How may this deplorable state of affairs be explained? The cancer victim seeks relief at a time when the disease is not any more confined to the uterus. Obviously a careful physical and bimanual examination would have enabled the surgeon to recognize the ad-

vanced state of the disease and pronounce the case inoperable and hopeless from a surgical standpoint. In other instances extension of the disease into neighboring organs or tissues cannot be determined in spite of an honest and careful investigation, a fact that is excusable. Again, in other cases, a correct diagnosis was not made at the first presentation of the patient, due to carelessness or inability to make the examination. Such a condition is inexcusable and criminal. If physicians would resolve to arrive at a correct diagnosis in every patient in the shortest possible time, or failing to do so refer the patient to someone who could, the percentage of cures of cancers would soon increase. Finally, a large number of cases remain that come to the clinic with advanced cancer disease. The patient, though ailing, did not realize the import of ill-health. It is, therefore, our duty to enlighten the public on the insidious onset of the disease, to teach it the cardinal symptoms that uterine cancer evinces, and to impress upon it the truth that cancer is curable if surgically eradicated in the beginning, that is, localized stage.

The examination of a cancer patient has as its object not only the diagnosis, but comprises the determination of the extent of the disease and the recognition of co-existing or complicating diseases. It would lead too far to discuss this subject in all its details, but we may enumerate the various steps of the examination. These are: 1, an exact history; 2, a careful general physical examination; 3, painstaking bimanual vaginal and rectal examination, and 4, special endoscopic examinations of the rectum and urinary system.

The digital rectal examination enables us to recognize invasion of the regional lymphnodes and the parametria. Cystoscopic examination reveals an invasion of the bladder; urethral catheterization may elicit obstruction of the ureter either by pressure or cancer invasion. By a proctoscopic examination we may recognize an invasion of the bowel, a fact which would have escaped a digital exploration.

A localized cancer is curable and operable. A cancer

that has invaded neighboring tissues or regional lymph-nodes is doubtfully curable by operative measures and is termed a border-line case. A cancer which has extensively invaded one or both parametria or the bladder in front or the rectum behind is inoperable. Co-existing complicating diseases may render the patient a bad surgical risk and, therefore, surgical treatment is out of the question. The indications for operative treatment must be solely based upon these facts.

One hundred and sixty-five cases of carcinoma of the uterus came under my care from April 1, 1914, to October 1, 1919. Twelve of these cases, or *i. e.* 7.27 per cent, were clearly operable, and twenty of these cases, or *i. e.* 12.12 per cent. were borderline cases, hence doubtfully operable. In other words, out of one hundred and sixty-five cases only thirty-two cases, or 19.39 per cent, could justifiably be subjected to an extended radical extirpation. If the statistics on efficiency of surgical treatment were applied to these thirty-two cases, then at the end of two years only about fourteen patients would have survived without a recurrence.

"The total number of cures of 1090 cases were 386 or 35.41 per cent of traced cases, or 19.32 per cent of cases operated on, or less than 11.72 per cent of cases applying for treatment." (Janeway-Surg. Gyn. & Obst., Sept., 1919.)

Indeed surgical treatment of cancer has been very unsatisfactory in the majority of cases and it is not surprising that we are straining all our efforts towards an improvement of the treatment of cancer in other directions. Since the advent of the modern transformer, the Coolidge hot cathode tube and the radio-active substances chiefly mesothorium and radium the discussion of the subject of cancer treatment has received a renewed impetus.

We must always realize that success in cancer treatment can only be obtained by the complete eradication or degeneration of absolutely all cancer cells present in the body of a victim of the disease. This principle must be observed if we are to expect results whether the means chosen are sur-

gical or radiological. The danger in the treatment of cancer with surgery consists in the fact that we cannot always remove all tumor tissue. The vestiges left grow with an increased rapidity and by auto-transplantation cause secondary growths in different parts of the body. The danger in the treatment of cancer with radio-active substances lies in the fact that proliferation is enormously stimulated if we cannot rapidly destroy all the pathological cells. An accelerated proliferation increases the danger of the formation of metastases. Earlier diagnosis has doubtless contributed to improving surgical statistics and is equally important for roentgen and radium therapy. In these directions lies the hope of real advance in the therapeutics of uterine cancer.

The demonstrable reduction in the size of a tumor of a kind not to be attributed to the natural process of evolution of that tumor or its associated lesions is the one essential feature of effective therapeutic intervention. Circulatory changes in the tumor, the cessation of hemorrhage, the relief of pain, the restoration of a secondarily impaired function or local healing cannot be cited as an indication of the specific curative action of the agent employed. The growth may continue to advance in spite of their presence. We should exclude from the consideration of the curative action of an agent all of these secondary factors. The observation of the size of the tumor itself is the sole criterion on which we can place reliance in judging of the effect of the therapeutic measures.

Surgery will remove cancer tissue and organs but cannot change the characteristics of the abnormal cells. The hard roentgen rays and the gamma rays of radio-active substances can modify cancer tissue and cells but cannot remove them. Surgical eradication of carcinoma of the uterus is so frequently followed by a recurrence because either an auto-vaccination of active virile cancer cells took place during the operation due to the inevitable trauma, or vestiges of carcinoma cells have inadvertently been left behind. If

the growth had been intensively rayed to destroy the boundless proliferative activity of the cancer cells the accidents of surgery would have been minimized or rendered impossible. An application of roentgen and gamma rays of sufficient intensity and extent to include all of the tumor mass and the regional lymphnodes will stunt the growth within ten to fourteen days on account of the arrest of mitosis of the carcinoma cells. If we keep these facts in mind we can approach the solution of the technique of cancer therapy with some prospect of benefit. If the case primarily was in an operable stage the excision should now follow. Another seance of combined roentgen and gamma rays is given as soon as the patient has recovered from the effects of the operation.

The patient must be requested to return for re-examination every six weeks during the first year and every three months during the second year and thereafter on the appearance of even mild symptoms of ill-health such as painful urination, difficulty in defecation, vaginal discharge or the slightest indisposition. If a recurrence should take place the same plan of treatment is again adopted, that is a course of ray-therapy followed by the operation if the recurrence is operable.

In borderline cases the question arises whether an operation would be insisted upon, or whether it is preferable to confine one's efforts to ray therapy. We had twenty cases in our total of one hundred and sixty-five. Thirteen were subjected to a combined surgical and radiological treatment, while seven were treated only with roentgen and radium rays. Our results seem to indicate that the patients treated with rays fared better in both immediate and remote results than those treated with a combination of surgery and rays. However the time elapsed is not yet of a sufficient duration to allow us to render a definite opinion.

In absolutely inoperable carcinomata of the uterus we solely have recourse to radiotherapy. Should a local healing and a reduction in the size of the tumor ensue, so that

the tumor seems to be localized within the uterus the question arises whether we should or should not resort to surgical eradication. Out of a total number of seventy-three cases we subjected thirty-six cases to operation, sixteen to panhysterectomies and twenty-one to very thorough vaginal cauterization with the hot soldering iron, while thirty-seven cases were treated with rays only. The results plainly are in favor of the last procedure. Only five patients remain alive in the first group, but thirteen in the second group. Thirty-two died or were not even improved by the combination treatment and twenty-four of the second class either died or were not improved. The duration of life following the combination treatment of those known dead is nine plus months, while it is twelve plus months in the second class. Therefore the patients were not only unnecessarily subjected to severe physical sacrifices, but fewer survived the ordeal and the duration of life of those, known dead, was also markedly reduced.

We next wish to discuss the technique of the ray-treatment observed in our clinic. We always use a combination of roentgen and radium rays. The equipment used to carry out the roentgen treatments consists of a transformer with an autotransformer current controller and a Coolidge tube. We use two methods: the crossfire method with a large number of small fields and the homogeneous method using two large portals of entrance.

The crossfire method is carried out as follows: The Coolidge tube is charged with a current of five milliamperes of ninety kilovolts as determined with the auto-transformer control. The rays are filtered through an aluminum plate of 4 mm. thickness. The focal distance is seven inches. The number of fields is from seven to twelve in the suprapelvic region and from four to eight fields divided over the perineal, sacral and buttocks regions. Thus from ten to twenty fields are used. Each field is one and one-half inches square. The duration of the application is ten minutes over each field, but may be extended to thirty minutes without

causing serious injuries in the skin. The erythem dosage obtained within ten minutes above the filter is six and on the skin surface one, or eighteen and three respectively if thirty minutes are used. Therefore a total of sixty to three hundred erythem doses is given during each seance of treatment. The ten minute seances are repeated after fourteen to twenty-one days for three times.

The homogeneous method is carried out in the following manner: The Coolidge tube is charged with a current of five milliamperes of a current of one hundred to one hundred and twenty kilovolts controlled by the auto-transformer. The filter consists of a 1 mm. copper plate and one thickness of sole leather. The focal distance is 24 inches. One field 9 inches square is used anteriorly and another one posteriorly over the sacrum. The application to each field is about one hour. The erythem dosage on the skin being 1.25 E. The difference in intensity of the ray at the skin level and the posterior pelvic wall is negligible. Therefore practically the same stream of rays passes through the pelvic structures assuring a complete and uniform penetration.

We are at work building a transformer that will deliver a current of 150 to 180 kilovolts and a tube that will carry this load. We are convinced that results will materially improve with the use of the latter method.

The method of measuring the erythem dose also is very incorrect and we are engaged at present in measuring the rays delivered at the posterior pelvic wall by a specially constructed ionisation chamber that can be inserted in the rectum and is connected with an electrometer provided with an indicator registering the number of electrostatic units obtained within a fixed time period.

In stating dosage of gamma radiations of radium we must observe:

1. Quantity of radium in milligrams of the element.
2. Filter, rubber filter and other wrappings used, such as gauze.

3. Distance of radium from area to be treated.
4. Time duration of exposure.
5. Intervals between each series of exposures.

In estimating the dosage in a given case, we must always consider that the cancer must be completely destroyed and that the dose applied must not produce serious injuries of the surrounding healthy tissues and organs which would render illusory the first object. The minimum dosage for destruction of cancer epithelium is on an average half as large as the minimum dose for the destruction of healthy skin epithelium. Exceptions are glandular carcinomata. The maximum dose is that necessary to destroy cancer without injury to healthy tissues. It can only be obtained by deep therapy in pelvic carcinomata. It is the object of deep therapy to influence by the rays deeply located pathologic processes in the body through layers of healthy tissue overlying the former without permanent injury to the latter.

The maximum dosage can only be determined by the biologic measurement of each radium preparation. If fifty milligrams of radium element contained in a tube as usually employed in gynecological work are filtered through 1 mm. of brass, 3 mm. of para rubber, 5 mm. of gauze and a finger-cot, then the maximum dose for healthy skin is one to one and one-half hours. The exposure causes no visible reaction. If the application is continued then a reddening of the skin occurs at about one and a half hours, an erythem dose; at two and a half hours it causes a blistering of the skin, a burn of the second degree, the lethal dose for healthy epithelium. If the application is continued for twenty-four hours then a burn of the third degree is caused in the epithelium, while the dose may be still considered lethal for connective tissue, *i. e.*, the connective tissue is not permanently destroyed or damaged.

To estimate the maximum doses for the destruction of a uterine cancer we must recall to our mind the exact abnormal conditions found in the pelvis in this disease. The

vaginal portion of the cervix lies in the interspinal line. The cervix and lowest part of the body with the parametria lies somewhat higher. Cervical cancers spread by invasion of the vaginal vault, by infiltration of the lymph vessels of the lateral parametria, the paravaginal tissues, along the sacro-uterine ligaments to the pararectal tissues and rectum, and through the vesico-vaginal septum to the bladder. The part of the pelvis between the pelvic outlet and a midpelvic horizontal plane contains all these structures and is the space which must be rayed. The transverse and antero-posterior diameters of the midpelvic plane are twelve centimeters in length, while the transverse diameter of the pelvic outlet is twelve centimeters and the antero-posterior diameter is eleven and one-half centimeters. Hence if radium is inserted into the cervical canal which lies in the pelvic axis, the rays must reach a penetration of five and one-half to six centimeters. We must avoid injuries to the ureters, bladder and rectum. They are on an average one and one-half centimeters distant from the cervical canal, if the hollow organs are empty. Should the bladder or rectum be filled, they are forced closer to the cervix and the distance is reduced by about one-half. Therefore it is desirable that bladder and rectum be empty and left empty during the treatment.

We may overdose the depth of one and a half centimeter to such an extent that the maximum dose for normal epithelial tissue is obtained at one and a half centimeter without injury to the ureters, bladder and rectum. Thus we may use a dose nine times the maximum of a surface epithelial erythem dose. Observing the law of the inverse ratio, and stating that the intensity of the rays is 100 at a distance of one centimeter, then it is one-fourth at a distance of two centimeters, one-ninth at three centimeters, one-sixteenth at four centimeters, one-twenty-fifth at five centimeters, one-thirty-sixth at six centimeters, and one-forty-ninth at seven centimeters. Since the maximum dose for cancer tissue is one-half that of normal epithelial tissue,

and the maximum lethal dose for normal epithelial tissue is reached at two and one-half to three hours, with fifty milligrams of radium at a distance of one centimeter it is attained in cancer tissue in about one and one-half hours. This we have repeatedly proven in skin cancers, where the depth of the tumor could be exactly gauged. Further if at one centimeter distance a destruction of cancer cells is obtained in one and one-half hours, at two centimeters it is obtained in six hours, at three centimeters in thirteen and one-half hours, at four centimeters in twenty-four hours, at five centimeters in thirty-seven and one-half hours, and at six centimeters in fifty-four hours. Therefore the application of fifty milligrams of radium element properly filtered must consume fifty-four to sixty hours to destroy all cancer tissue in a pelvic cancer. The maximum dose at one and one-half centimeters for the normal bladder and rectum epithelial tissues is reached at about twelve hours. We may assume that if a dose is applied for only ten hours it destroys cancer tissues within two centimeters while the healthy bladder and rectum epithelium is not injured to cause permanent damage. If a sufficient interval is left between subsequent applications, the normal tissue regenerates, so it will bear another exposure without permanent injury, while the cancer tissue, however, is permanently damaged and cannot regenerate. Thus the plan of the intermittent application was developed. Fifty milligrams of radium element properly filtered are inserted on six to seven successive days for ten hours each day. Strictest asepsis must be observed. It is also advisable to maintain free drainage from the uterus. The rapid disintegration of cancer cells liberates besides antigens, hemolytic and proteolytic ferments. If drainage is obstructed or prevented they may lead to hemolysis and proteolysis and cause grave disturbances of the general health.

The reasons why we do not apply the total dosage in one sitting is to prevent destruction of healthy organs and to avoid severe auto-intoxication.

Results

From April 1, 1914, to October 1, 1919, one hundred and sixty-five cases of carcinoma of the uterus were treated. For a study of the clinical value of ray therapy, we have divided the cases into five groups.

Group 1. Cases which were clearly operable after a physical examination.

Group 2. Cases which were doubtfully operable.
- (a) Cases subjected to surgery and ray therapy.
- (b) Cases subjected to ray therapy only.

Group 3. Cases in which an operation was absolutely impossible.
- (a) Cases subjected to abdominal hysterectomy and radium and ray therapy.
- (b) Cases subjected to vaginal cautery and ray therapy.
- (c) Cases subjected only to ray therapy.

Group 4. Cases so far advanced that all treatment was hopeless. They were subjected to ray therapy for purposes of palliation.

Group 5. Cases that recurred after an abdominal panhysterectomy.

The following table shows the total number in each group and the results to date.

Group	*Total Number*		*Living*	*Died*	*No Report or Improvement*
1	12		10	2	
2a	13		7	3	3
		20			
2b	7		5	2	
3a	16		2	11	3
3b	21		3	8	10
		73			
3c	36		11	12	13
4	28		1	13*	14
5	32		5	11	16
	165		44	62	59

*Three died within a day or two after the treatment from severe toxemia.

A study of all the tables demonstrates at once the importance of early diagnosis and treatment. We can only hope for improvement in cancer cure statistics by instituting measures resulting in an earlier recognition and immediate proper treatment of these carcinomata.

The clearly operable cases make a remarkable and favorable showing. There are two deaths in a total number of twelve cases treated. The cases surviving do not evidence a sign of recurrence at the present writing.

In Group 2 twenty cases were treated. Of these thirteen were subjected to operative and ray therapy. Of these seven are living while six either died or did not report. Of the seven cases treated only with rays five are living and two died. It is impossible to state whether an operation should have been performed or not as the cases are too few and too recent to permit a conclusion. But it appears to us that surgical eradication does not materially influence the results for the worse.

It is not surprising that Group 3 should give us the largest number of cases, namely seventy-three. Of these sixteen cases were subjected to hysterectomy either before ray therapy was begun or after a local healing was obtained with ray therapy. The results were disastrous. Only two patients so far have survived the ordeal. Twenty-one cases were subjected to an initial vaginal cautery before radium was applied. Three patients survive to date, while the average duration of life in those known dead is twelve months. On the other hand eleven of the thirty-seven patients treated only with radium therapy are well at the present writing. The duration of life of those that died in class (a) is nine plus months, in class (b) twelve minus months, and in class (c) twelve plus months. In other words the patients in the latter class had a better chance all around than those in the former. We must conclude that if local healing is obtained, the tumor is arrested in growth and the infiltration of the parametria subsides, we should not subject the patient to an unnecessary operation.

Group 4 demonstrates one fact. An advanced cancer patient should be treated only with ray therapy to relieve the symptoms. This is all we can hope for. But little benefit is obtained for the efforts spent.

The intensive intermittent plan of treatment cannot be carried out in this class of cases as the rapid degeneration of tissue invariably causes a severe autointoxication. A period of from four to eight days should intervene between applications, that is until the reaction has subsided.

Group 5 shows a few brilliant therapeutic results. Recurrent carcinomata are very refractory to radium treatment. Comparing this group with Groups 1 and 2 we must state that a combination of surgical treatment and ray therapy shows such favorable results that surgical eradication of carcinomata must always be combined with an intensive ray treatment. If we procrastinate matters and postpone the latter until recurrences appear, and they do appear in about 75 per cent of the cases within the first two years following the operation, then ray treatment also cannot improve the outlook in the majority of cases. It is our opinion that the sooner after operation the recurrence took place the better the palliation from ray therapy.

A good deal has been said about the efficacy of emetine given intravenously in carcinomata. We employed it in twenty-five consecutive cases, six of which were uterine cancers. We did not see a single benefit occur to the patients, but found that they developed a severe weakness, a rapid and weak heart, loss of weight and strength and so forth, not to mention two immediate deaths and other transitory but alarming accidents attributable to the emetine.

Considering that surgery can remove carcinoma tissue, but not change the boundless proliferative activity of the cancer cell and that radium and the roentgen rays will arrest the active mitotic power of cancer cells but can not remove them, it is obvious that in the treatment of cancer disease we must resort to the combined method of treatment

provided the case in question is a clearly operable or doubtfully operable one. However, if the case is absolutely inoperable or recurrent we must confine the treatment solely to ray therapy. The hopeless case remains hopeless even if ray therapy has been carefully carried out.

Ray therapy is still in an experimental stage. As experience enlarges we will be enabled to form an exact technique. Results then will obviously be improved.

Fig. 3.

Left: Cervix before Treatment.
Right: Cervix Five Weeks after Treatment.

Uterine Cancers.

Table I. Classification.

Group I. Cases which were clearly operable after a physical examination.

Group II. Cases which were doubtfully operable „Borderline Cases."
a. Cases subjected to Surgery and Ray Therapy.
b. Cases treated with Rays only.

Group III. Cases in which an operation was absolutely impossible.
a. Cases subjected to abdominal Panhysterectomy and Raying.
b. Cases subjected to vaginal Cautery and Raying.
c. Cases subjected to Raying only.

Group IV. Cases so far advanced that all treatment was hopeless. They were subjected to Raying for purposes of palliation.

Group V. Cases that recurred after surgical eradication.

Group.	Total Number	Living	Died	No report or improvement.
I	12	10	2	
II a	13	7	3	3
II b	7	5	2	
III a	16	2	11	3
III b	21	3	8	10
III c	36	11	12	13
IV	28	1	13	14x
V	32	5	11	16
	165	44	62	59

x Three patients died within a few days from treatment.

Table 2. Time elapsed since treatment in living and dead.

Group I					Group II a					Group II b.				
Living		Dead		No Report	Living		Dead		No Report	Living		Dead		No Report
yrs	mths	yrs	mths		yrs	mths	yrs	mths		yrs	mths	yrs	mths	
5	2	1	10		4	8	2		3	2		1	1	
4	9		7		2	9	1			1	6	1	2	
3	6				2	6	1	5		1	4			
2	5				1	7				1	2			
4	6					8				1	3			
1	8					9								
1						6								
	9													
1	3													
1	2													
10		2			7		3		3	5		2		
Total 12					Total 13					Total 7				

Table 3.

Group III a.					Group III b.					Group III c.				
Living		Dead		No Report	Living		Dead		No Report	Living		Dead		No Report
yrs	mths	yrs	mths		yrs	mths	yrs	mths		yrs	mths	yrs	mths	
	6		4	3	2	9	1	1	10	2	2		7	13
	4		2		2	7		8		1	2	2	10	
		2	7		2			2			10		8	
			5				1	6			10		2	
			3					3			10	1	4	
			5				2	1			8	2	1	
			7				1	8			5		8	
			3					6			5	1	3	
		2									4	1	4	
			10								3		8	
			8								3		10	
													2	
2		11		3	3		8		10	11		12		13
Total 16					Total 21					Total 36				

Table 4

Group IV					Group V				
Living		Dead		No Report	Living		Dead		No Report
yrs	mths	yrs	mths		yrs	mths	yrs	mths	
4			4	14	3	3		11	16
			2		3	1		5	
			1		2	4		1	
			5		1	4	1	7	
			5			10		8	
			7				1	4	
			2					6	
			2					3	
			2					8	
			0					4	
			5					9	
			0						
			0						
1		13		14	5		11		16
Total 28					Total 32				

PHYSICAL FACTORS UNDERLYING THE USE OF RADIUM AND RADIUM EMANATION

GERALD L. WENDT

I. THE RADIATIONS FROM RADIUM SALTS

The complexity of the radiations from an ordinary tube of radium can hardly be overemphasized. The mere division into three classes, alpha, beta, and gamma, is only a preliminary step, for there are present in every such tube at least seven, and usually more, distinct elements, each of which has its own characteristic rays, of one, two, or even all three of these classes, and each of these is incomprehensibly complex. In the clinical use of radium this complexity is often lost sight of, a fact which has hampered the development of radium therapy.

It is well known that these rays arise from the explosions of the radioactive atoms themselves, and that we are here dealing with a source of energy quite different from the usual types. Realization of the amount of this energy is not so common. Radium keeps itself constantly two or three degrees above the temperature of its environment, due to the absorption of its own rays. The heat thus evolved amounts to about 134 gram calories per hour from a gram of radium in equilibrium with its decomposition products. Of this 25 calories come from the radium itself, and 109 from the gaseous emanation and its products. A brief calculation shows that one cubic centimeter of the emanation under these conditions gives no less than 24,300,000 calories before it ceases radiating energy. That this is a stupendous quantity of energy can be shown by comparison with the heat liberated from an ordinary chemical reaction. One cubic centimeter of mixed hydrogen and

oxygen gives, in one of the most energetic of all known chemical reactions, two calories. The same quantity of radium emanation gives more than ten million times this quantity. Obviously the two are not comparable. In the one case we are merely scratching the surface of the atoms. In the other deep-seated changes take place, and a large fraction of the total energy contained within the atom is made available. Radioactive change of one element into another is a wholly different thing from a chemical reaction. Even the analogy of comparing the chemical heat with the water evaporated from the surface of a watermelon and the radioactive energy to the entire water content of its interior falls short of the truth.

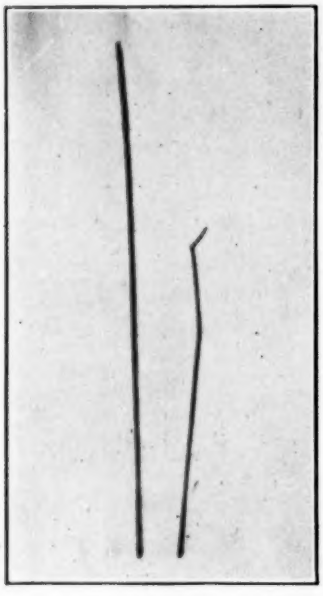

FIGURE 1

THE STRUCTURE OF THE ATOM

The anatomy of the radium atom needs to be understood before the distinction becomes clear. This was first deduced by Sir Ernest Rutherford from experiments made by

himself and by C. T. R. Wilson. The latter succeeded in making photographs of the trajectory of an alpha ray in its course through a gas. One such photograph is reproduced in Fig. 1. The fact of note is that the swiftly flying alpha particle suffers two very marked deflections, presumably in colliding with atoms of oxygen or of nitrogen in the air. This is a rare exception. In general these particles pass without hesitation through the atoms which lie in their path. Even thin sheets of gold or of glass do not stop the rays and bend only a very small proportion out of their path. The sharp deflection in the photograph was not due to any impurity in the air, and since many other atoms of gas were passed through without incident it follows that in these particular two collisions the alpha particle must have struck the gas atom *in some unusual part of its anatomy.* Hence Rutherford concluded, from this and many other similar experiments, that almost the entire mass of an atom is concentrated in a very dense nucleus at its center and that in these two collisions the alpha particle passed very close to this dense nucleus, while in the ordinary collisions it passed through the relatively empty exterior of the atom. This nucleus theory of the atom has been elaborated mathematically, and has furnished the explanation of so many otherwise unintelligible phenomena that it is now almost universally accepted.

On this theory the diameter of the nucleus is about 10^{-13} cms. This is only one hundred-thousandth of the diameter of the hydrogen atom, 10^{-8}, yet practically all the mass of the atom is condensed into this nucleus. The outer part of the atom is composed of rings of electrons in rapid motion, like planets about the sun. To these electrons the chemical properties of the various elements are due, and it is with this exterior that we usually deal. In radioactivity, however, we are only incidentally concerned with the electrons: the rays come from the nucleus. It is only by means of the rays that we obtain any information as to the nature or even the existence of the nucleus. A complete study of the

structure of the nucleus has recently been made by W. D. Harkins.[1]

The Alpha Ray Disintegrations

While the planetary electrons are knocked out of the atom very easily, the nucleus is very stable in all atoms except those which for some reason are "radioactive". In these the nucleus explodes. Of course each radium atom can explode but once, for what remains cannot be radium; it is, in fact, quite a different substance. Whether any individual radium atom "lives" for a second or for millions of years is a matter of chance. But with the enormous number of atoms in a gram this chance becomes a certainty and the number of radium atoms which explode per second is strictly proportional to the number present. Of every million radium atoms present at any time 346 will explode per year or about 0.00001 per second. With 100 billion radium atoms one explodes per second. Since there are 10^{21} atoms in a gram of radium, however, such a gram gives ten billion such explosions per second. This means that in about 1800 years any quantity of radium will have been reduced to one-half its original amount.

Now, as stated above, the energy liberated in these explosions is tremendous. What happens is the ejection from the nucleus of a smaller nucleus, four units in atomic weight, at a velocity of 1.6×10^9 centimeters or about 10,000 miles per second. All radium explosions emit these particles, the "alpha rays", which are really nuclei of helium atoms, at this same velocity. On encountering material obstacles they give up their energy in collisions and are reduced to a velocity such that we can no longer detect them when they have gone through 3.3 centimeters of air. Since they all have the same velocity they all go just this same distance before they are lost, so that this distance is characteristic and is known as the "range".

[1] The Nuclei of Atoms and the New Periodic System. *Physical Review*, 15, 73, February, 1920.

What remains of the original radium atom is of course projected in the opposite direction according to the laws of momentum at a velocity which is relatively smaller because of the greater weight of the particle, namely, 222 units of atomic weight, radium itself having an atomic weight of 226. These are called the "recoil atoms". They are no longer radium. Not only has the nucleus lost four units of weight in the explosion, but, since it is composed of positive electricity, and two units of positive electricity go off with the helium nucleus, what remains is negatively charged due to the excess of electrons on the outside of the atom. This cannot last, however, and two electrons at once drop off. But these are valence electrons and hence the new atom has a valence two less than the radium. Now radium is in the group of the periodic system with barium, and has a valence of two. The new atom therefore has a valence of zero, and is, in fact, a member of the group of noble gases in the periodic system, along with neon, argon, etc. It is called niton, or more usually, radium emanation. Why it is a gas rather than a solid is not clear, but it is in every respect a chemically inert gas just like the other gases of that group.

These atoms of the emanation are much less stable than those of radium. One out of every 500,000 explodes per second, and any quantity is thus reduced to half value in a little less than four days. Starting with pure radium, there will of course at first be no alpha rays from the emanation, and during the first minutes after purification the emanation will be so small in quantity that the rays from it will be but a small fraction of those from the radium. As time goes on, however, more and more rays come from the emanation. Take 100 billion radium atoms to start with. One explodes per second. When 500 have thus been converted into emanation these latter will be exploding at the rate of one every thousand seconds. By the time 500,000 atoms of emanation have formed, they will be exploding at the rate of one every second. Hence they are exploding as fast as they are formed. No quantity in excess of these

500,000 can thus be accumulated at any one time from this amount of radium. The two are said to be "in equilibrium". This will occur within a month after all the emanation has been separated from the original radium.

The emanation has a shorter life than the radium. Along with this goes a greater energy of explosion. Its alpha rays are projected with a velocity of 1.7×10^9 cms. per second and have a range of 4.2 cms. in air. They all have the same velocity and range, but these are different from those of radium itself. The range of the alpha rays can thus be used as a test to distinguish the two substances. Indeed every radioactive substance that emits alpha rays has its own characteristic range, dependent only on the energy with which it explodes.

The product of the explosion of the emanation atom, called Radium A, has an atomic weight of 218 and is again two places to the left in the periodic system. It is thus in the sixth group, since the zero group and the eighth group are chemically the same in this regard. It thus resembles tellurium and has a valence of six. It also is unstable, even more so than the emanation. One out of every 250 atoms explodes per second, so that it is reduced to half value in three minutes. Thus for every 500,000 emanation atoms, and for 100 billion radium atoms only 250 atoms of this Radium A can be formed before it decomposes as fast as it is formed. It rapidly reaches equilibrium and emanation is thus never handled free from it. It can however be distinguished by its longer range, which is 4.75 cms.

In a similar way the life periods and ranges of the one further product that gives alpha rays, Radium C′, can be distinguished. Radium B is an intermediate product which does not give alpha rays on exploding, and will be discussed later. After Radium C′ comes Radium D, whose period is so long and whose activity is therefore so small that it need not be considered.

Thus every sample of radium in a sealed tube gives out four different kinds of alpha rays, corresponding to the

four different successive products which break up with the emission of a helium nucleus. If the products have reached equilibrium with the radium, as occurs within a month, there will be four alpha rays emitted for every radium atom that explodes. Similarly, the emanation separated from radium will reach equilibrium with its products within three hours, and will then give three alpha rays for each atom of emanation which explodes.

Use of Alpha Rays

While these explosions in which alpha rays are emitted are the most violent of the radioactive transformations and give about 93 per cent of all the energy that is lost by radiation, this energy can only rarely be used. These rays are effective in producing many chemical reactions, such as the formation of ozone from oxygen, or hydrochloric acid from hydrogen and chlorine, etc. But for this purpose the radiating substance must be exposed directly to the reacting substances. The walls of an ordinary container would absorb the alpha rays completely. It is possible to use the gaseous emanation in glass tubes so thin that the rays pass through, but the glass may be no thicker than a sheet of tissue paper. If the alpha rays from radium are to be used, the radium must be applied directly or through a very thin coat of varnish. Since the alpha ray of maximum range in air penetrates only 7 cms. of air, and the stopping power of a substance is roughly proportional to its density, and, finally, since the density of ordinary materials is about a thousand times the density of air, it follows that the rays cannot penetrate more than 0.007 cms., or less than a tenth of a millimeter of any solid or liquid. The penetration is, in fact, only a few hundredths of a millimeter. Only carefully designed "direct applicators" therefore allow the use of these rays.

Furthermore, the rays are of no value except in the treatment of very superficial growths, since they cannot penetrate into the tissues. Obviously, as in all chemical

reactions, the application of energy to a system has no effect unless that energy is absorbed by the system. A perfectly transparent substance can never be changed by light. So also if the deeper layers have no opportunity to absorb the alpha rays they can have no effect.

For these reasons we are not concerned as to the possibility of separating the three or four different species of alpha rays from each other. This can be done by interposing very fine screens which absorb the weaker rays and allow the faster ones to pass, but this has no practical purpose.

It is important, however, that the alpha rays can be thus easily absorbed and removed from the more useful beta and gamma rays. Indeed, care should be taken when the latter rays are used that all the alpha rays are absorbed, since they otherwise cause severe surface burns, being about ten times as effective where they do go than are all the other rays together.

The Beta Ray Disintegrations

It has been stated above that Radium A, which gives alpha rays and is reduced to half value in only three minutes, produces Radium B. Since the former is in the sixth group of the periodic system, the latter is in the fourth group, being analogous to lead, though it has an atomic weight of 214. This substance is also unstable. Its explosions, however, are of quite a different nature from those of the elements we have heretofore considered. It explodes rapidly, so that it is reduced to half value in slightly less than half an hour. But it does not emit alpha rays. All the characteristics of the previous elements are missing. In their stead we observe the emission of rays that are much more penetrating, but which have individually much less energy than have the alpha rays. It has been shown that instead of being positively charged, they are negative, and instead of being of atomic size they are several thousand times smaller. They are, in fact, electrons, and are iden-

tical with the atoms of electricity which constitute an electric current when they flow through a wire or through an air gap.

These electrons differ from all other known electrons in their tremendous velocity. Some of them are ejected from the atoms of Radium B at a velocity which is 99.8 per cent of the velocity of light; that is, more than 180,000 miles per second. To give an electron such a velocity in air requires a potential of several hundred thousand or even a million volts. This fact alone indicates that these electrons, or beta rays, do not come from the surface of the atom, but from its nucleus, where the forces are condensed and sufficiently intense to account for these high velocities.

Another fact which indicates that the beta rays come from the interior rather than from the surface of the atom, is the change in chemical properties which ensues. Radium B has a valence of four, hence has four surface electrons. If it were one of these that was ejected, the valence should become three. As a matter of fact, the product of this explosion, known as Radium C, has a valence of five, and is chemically analogous to bismuth. This is explicable only on the assumption that the beta ray has come from the nucleus, that this therefore acquired an additional positive charge, and that this must be neutralized on the surface of the atom by the acquisition of a stray electron. One of the myriad electrons which are wandering everywhere throughout matter, is appropriated and becomes bound in the surface of the Radium C atom as a valence electron, giving to Radium C a valence of five, where Radium B had but four.

While the amount of energy carried by each one of these beta rays is less than one per cent of the energy of the much larger alpha particle, its velocity is so high that it penerates considerable thicknesses of matter. They can be detected after passage through as much as a meter of air. They pass through as much as 3 centimeters of aluminum. This is due to their velocity and their small size, which allows them to pass through the majority of

atoms without encountering material resistance. As stated above, the aggregate space occupied by an atom is probably less filled with matter than is the space occupied by the solar system. Like meteors in the astronomical analogy, they can therefore pass through what we consider solid matter with relatively few collisions.

It was stated above that all alpha rays from any one element have the same velocity as determined by their range. This is not true of the beta rays. Their velocity is most easily determined by deflecting them from a straight line with a magnetic field. When this is done the beta rays from Radium B, for instance, are shown to vary widely in their velocities, and, what is more strange, there are no less than thirty definite groups of velocities, all from this one substance. It seems obvious that any two atoms of Radium B must explode in the same manner, and that these groups of rays are therefore due to the various adventures of the electrons in their passage out of their parent atoms. For practical purposes it is important simply to know that the velocity, and therefore the penetrating power, of these rays varies by tenfold.

The product of this disintegration, Radium C, though it has a valence of five and is chemically very different from its parent, Radium B, has the same atomic weight as the latter, 214. The loss of the electron or beta ray does not decrease its mass by an appreciable extent, although all the other properties change. This Radium C also emits beta rays of various velocities and forms a product, Radium C′, which has a valence of six and gives again alpha rays, as mentioned above.

The Gamma Rays

The emission of beta rays is invariably accompanied by the emission of gamma rays. These latter are radiations in the true sense, *i. e.*, they are not material particles, as are the first two classes mentioned, but are ether waves, similar to light and *x*-rays. They are distinguished from

x-rays only by being much shorter in wave-length. Visible light waves are between 0.0007 and 0.0004 mms. in length, or in the more usual units, between 7000 and 4000 Angstrom units. As the wave-length of light decreases all matter becomes more opaque to it until at about 1300 A. U. all solids are entirely opaque. Much shorter wave-lengths, however, again penetrate, and when we reach a length of only one A. U. we have *x*-rays with their extremely great penetration. The shorter the wave-length the more penetrating an *x*-ray is. Hence the gamma rays, which are in fact *x*-rays with a wave-length of about 0.1 A. U., are the most penetrating of all known rays.

They are generated in the radium just as *x*-rays are generated in a tube. In the latter case a stream of electrons is projected through an evacuated space under a high potential, and thus strikes the material of the anticathode or target at a high velocity. The energy of the collision is radiated largely in the form of short-wave radiation or *x*-rays. The intensity of the *x*-ray emission depends only on the number of electrons passing, *i. e.*, on the milliamperage. The wave-length of the *x*-rays, however, depends on the velocity of the electrons, *i. e.*, on the potential or the spark-gap. The higher the potential the greater the frequency and the less the wave-length of the *x*-rays. It is of course well known that increase of potential gives "harder", *i. e.*, more penetrating and thus shorter wave-length *x*-rays. The conditions within the radium tube are the same. Atoms of Radium B and of Radium C are constantly exploding and sending out the electrons in the form of beta rays. These collide with the atoms of the various types of radio-active elements present in the tube and the energy of the collision is similarly radiated in very short waves. But since the energy with which the electron is sent out is much higher than from any potential obtainable in an *x*-ray tube, the rays thus generated have a correspondingly shorter wave-length. The extremely penetrating gamma rays from Radium B correspond to a potential of 200,000 volts and

presumably it is an intra-atomic field of about this strength that projects the beta ray electron.

As stated above, the beta rays from Radium B fall into some thirty different groups of velocities, and thus there are also many groups of wave-lengths in the gamma ray spectrum of this substance. In addition Radium C is present in every radium tube and contributes its own types of gamma rays. Finally, since the velocities of the beta rays are continuously reduced before they finally emerge from the tube, there is also a general distribution of gamma ray wave-lengths, a continuous spectrum.

While the potentials within the radioactive atoms are higher than those conveniently attainable in *x*-ray work and the gamma rays are thus more penetrating than *x*-rays, the intensities of the latter can be made much the greater. The intensity of such radiation is proportional to the number of electron collisions, and thus can be increased at will to very high values in *x*-ray tubes, while any one radium tube gives a constant intensity dependent only on the amount of Radium B and C it contains.

The Use of Beta and Gamma Rays

Both these rays may be used in therapy, but the beta rays can never be used without the gamma. Since the latter are so much more penetrating they cannot be separated from the beta rays by fractional absorption, and since they are light waves they cannot be deflected or removed by other means. Beta ray treatments must therefore count on the presence of the more penetrating though less powerful gamma rays. The energy of the gamma rays is only about one per cent of that of the beta rays. For beta ray treatment the radium tube must be used almost bare, *i. e.*, it must not be inclosed in lead. Two millimeters of lead will completely absorb the beta rays and two millimeters of aluminum will absorb ninety per cent of them. A bare tube will give a beta ray penetration of five to ten millimeters in tissue.

This penetration is so low that the gamma rays are

much more useful. For effective use without danger of surface burns the tube is covered with a layer of lead to absorb the beta rays. Since gamma rays are more penetrating than x-rays the question of their effective range is only one of intensity. Their energy per square centimeter of course decreases with the square of the distance from the tube, as with all other radiations, and hence to reach deep regions it is often necessary to use "cross fire" methods such that the spot aimed at receives repeated doses from various angles, while surrounding tissues are radiated only once from some one of the points of application. When a tube is inserted in a body cavity and the rays are to be used in one direction only, the back of the tube must be covered with heavier lead to prevent the escape of intense radiation. While even a centimeter of lead does not absorb the gamma rays completely, their intensity may thus be cut down to a point below that of effective dosage.

The ability to apply the tube directly to the surface of the lesion in this manner is of course one of the advantages of radium therapy. Because of the inverse square of the distance law, however, in such usage the intensity and therefore the effectiveness of the rays dies off rapidly. When the tube is at some distance from the lesion this is not true, and a uniform dose may be given to a large area. It should be noted that this law of decrease holds only for light radiations and is not exactly applicable to the material rays like the beta.

One more point should be mentioned. There is a close relation between the electrons which cause x- and gamma rays and those rays. The reverse process is equally common. Thus the passage of either x- or gamma rays through matter liberates large numbers of electrons. In the case of the very high frequency gamma rays these liberated electrons themselves attain high velocities, and are, in fact, beta rays. This is also true of the x-rays, although the frequency of the ray is less and the velocity of the liberated electron is less also. Furthermore, the x-ray tube is com-

monly at some distance from the point under treatment, so that these secondary electrons are dissipated. With a radium tube, however, they may be liberated at the very surface of the lead covering which excludes the primary beta rays, and may thus cause a surface burn in spite of heavy lead protection. For this reason the lead tube should be placed within a thin rubber tube. This will absorb the secondary beta rays from the lead and will itself emit very few electrons under the action of the gamma rays.

The chemical and therefore the therapeutic action of the beta and gamma rays is much the same, and they may be used interchangeably when their penetration and energy are borne in mind. The mechanism of this action will be discussed in a later paper.

It will be noted that the beta and gamma rays are evolved exclusively by Radium B and Radium C and not by the radium itself. These beta radiators are themselves products of the radium emanation, a fact which has led to the wide use of the emanation itself in place of radium tubes. This has many advantages, which will be dealt with in the second paper of this series.

RADIUMTHERAPY OF THYROID*

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In dealing with this subject we shall limit our discussion to the vascular variety of thyroid disease. We have had no experience in treating goiter of the hypothyroid form with radium, in fact, this being a non-functioning form it would seem that any process that would interfere with the blood supply of the gland would be injurious and perhaps accentuate the existing condition. We have treated 31 cases of exophthalmic goiter of varying degrees of severity, the first case being treated in September, 1917. The age of the patients varied from 74 to 16 years. Only two of the patients were young. One as stated 16, the other 19. These were both cases with pronounced exophthalmic symptoms and were not physiological goiters at all. It is known to all of you that the tunica intima of the blood vessels is exceedingly susceptible to the radium ray eventuating in an obliterative endarteritis, also it is well known that a new cell or diseased cell is usually many times more sensitive to radium than an adult cell. Working on these two premises it would seem natural that a growth of great vascularity and containing new growth cells should give reaction if treated with radium. Attempt has been made to ligate more or less of the thyroid arteries to starve the gland into subjection. Surgical attempts have removed a portion of the gland but the former process, of these two, only attacks the blood supply, not the degenerative cells, and the latter process while removing parenchymatous tissue along with the diseased part certainly left behind diseased tissue in the remaining portion, and the blood supply to this part more or

*Read before Western Roentgen Society, December, 1919.

less undisturbed. It is consequently only a question of time for there to be further degeneration and more toxic substances poured into the blood streams with further reduction of the normal functioning tissues of the gland. Of the 31 cases that we have treated with radium, six had already been operated with recurrence of symptoms as bad or worse than before. We have had to ray five cases the second time as the dosage was probably inadequate. One patient has taken up Christian Science, apparently not benefitted by the treatment; two with very bad broken compensation of the heart have died since treatment from acute dilatation, one 3 months after treatment, the other 5½ months, though in both cases the pulse had been slowed an average of thirty beats and the nervous symptoms were considerably reduced. In one case out of five there has been no reduction of the goiter. The others have diminished from ¾ of an inch to 3¼ inches in circumference. One woman patient, age 35, was burnt, the burn healing in twenty-four days and leaving a white scar the size of a nickel on her neck. Her goiter also did not go down until thirteen months had elapsed and suddenly the neck circumference diminished 1⅝ inches in a space less than two months. There has been symptomatic cure in all of these cases with the exceptions noted. The pulse beat has usually been reduced twenty to fifty beats, the nervous symptoms and tremor have vanished; exopthalmos has become less marked or disappeared entirely; patients have gained in weight and general well being. Certainly how permanent this will be we do not yet know, as our first case dates back only about twenty-seven months and thirteen cases have been treated during this present year.

At the risk of being somewhat tedious, we shall describe in detail the technic employed, having observed that the articles written and published appertaining to radium treatment contain a vast amount of information as to what is being done but with practically no information as to how the man did it, and that would seem to be quite essential, if

it be published with a desire to be helpful. We first rayed goiters in this manner. We divided the neck area into rectangles 1½x¾ of an inch dimension. We placed upon each square a radium tube containing 25 milligrams of radium element screened with a ½ millimeter of silver, one millimeter of brass and two millimeters of para rubber and left in situ for two hours. The whole goiter was covered in this manner. We found that there was considerable hyperemia of the skin, a few cases taking on a bluish appearance apparently suggestive of a burn though this did not take place. The action on the goiter was effective but it seemed that too much action was wasted upon the skin, so we manufactured a lead cone open at the bottom and the top, the sides composed of lead 3 millimeters in thickness—the bottom of the cone 2¼ inches square, the top 1 inch. Two thicknesses of rubber glove were placed over the bottom of the cone; it was then stuffed with cotton until an altitude of 1 inch was attained and then 100 milligrams of radium element placed upon this, using ½ millimeter of platinum and 1 millimeter of lead and the top then covered with cotton, lead and adhesive plaster. The average neck can be treated with two applications of the cone. A line is drawn down the center of the neck, other lines on each side of this ¼ of an inch away and then a square is marked out with indelible pencil so that when the cone is placed upon the tumor the lines are just visible all around. In some of the larger goiters it has been necessary to map out three squares, one over the isthmus and one over each lobe. The cone is strapped in place with adhesive plaster and usually left for six hours on each square. In a few of the more exaggerated conditions we have increased this exposure up to twelve hours and we have noted that there is scarcely a reddening of the skin but there seems to be most efficient action given by the gamma ray upon the thyroid tissue. Usually these patients seem a little worse for the first few days or week due to some edema of the gland but after about two weeks, improvement begins and at the end of a month the improvement is decided.

We would simply say in closing, that eleven cases in our series of thirty-one had been declined as operable risks by some of the best surgeons in the country and that these patients, several of them wives, sisters and aunts of physicians are now enjoying good health and attending to their regular duties.

25 E. Washington St.

THE ELEMENTARY PHYSICAL CHEMISTRY OF THE DEVELOPMENT OF *X*-RAY FILMS AND PLATES

MILLARD B. HODGSON
Rochester, N. Y.

THE EMULSION

A photographic plate consists essentially of a sensitive emulsion coated on glass. This emulsion is, of course, coated while in a liquid state and dried down in a layer which is about one-thousandth of an inch thick in the average *x*-ray plate or film.

Fundamentally the emulsion consists of a suspension of silver bromide in gelatine. It is prepared by adding together in a gelatine solution silver nitrate and potassium bromide in proper proportions, the essential reaction being that the silver unites with the bromine to form silver bromide. Were this reaction to take place in a strictly liquid solution, the silver bromide crystals formed would sink to the bottom, forming a white precipitate. In the gelatinous solution, however, they remain in suspension and form, after coating, the sensitive units of the photographic plate or film.

THE PHYSICS OF EXPOSURE AND DEVELOPMENT

Silver bromide, as found in the photographic emulsion, occurs in the form of more or less perfect crystals belonging to the cubic system. In the average plate they are usually in the form of thin, fragmentary slabs of various shapes, a great many of them being triangular. Some of these formations are shown in Fig. 1, which is a micrograph made at a magnification of about 1,000 diameters. These silver bromide crystals in the finished photographic plate are sensitive to light. They are also sensitive to

x-rays and other forms of energy, whether applied in the form of heat, friction or chemical change. They are "sensitive" in the sense that they will record the relative amount of action on them by any of these agencies. The reaction which occurs in a silver bromide crystal when exposed to light or *x*-rays, however, is so small that it cannot be measured by any direct physical or chemical means. By treating exposed emulsion, however, with solutions called "developers", the bromine is removed from the grains affected by exposure, leaving metallic silver. Reduction of each grain is a steady transition from silver bromide to silver, the bromine being taken up by the developer. The grains not affected by the exposure, and hence undeveloped, are then dissolved in a suitable solution. Changes occurring in the development of silver bromide grains are shown in Fig. 2.

It has been found that a crystal which has been exposed to light so that it becomes developable is entirely developable, provided sufficient time is given for the action of the solution. This can be seen by inspection of the micrograph in Fig. 3, which shows a single grain at two stages of its development.

The silver grains of the visible image in the negative are thus formed in practically the same space occupied by the parent crystals. This is illustrated in Fig 4, which is a micrograph of the *same* grains, before and after development. During development the reduced silver is deposited in ultramicroscopic particles, so that the completed grain appears like a collection of black soot embedded in the gelatine. When this phenomenon is watched under the microscope the transition seems very similar to the popping of a kernel of corn, for in most cases the shape of the original crystal is somewhat distorted.

THE LATENT IMAGE

The reaction which takes place when light strikes the silver bromide crystal is generally termed "the formation

of the latent image", and there are numerous theories which seek to explain the nature of the change. Mees[1] gives figures on the approximate amount of energy involved in forming a latent image in a high speed photographic plate, and deduces from these computations that the energy involved in making a silver bromide crystal developable is of the order of that involved in the liberation of an electron from one molecule of silver bromide. It is, of course, too small to measure by any known direct laboratory methods.

THE DEVELOPER

The development of the latent image in a photographic plate is a complex chemical reaction; for in addition to the delicate materials in the plate itself, there enters into the reaction four other distinct compounds, each in solution. Considering then, that there are seven primary substances entering into the process of development, from which there are formed additional compounds, one can easily see the necessity of confining the possible reactions to a minimum by the use of standard materials and standard methods.

Broadly speaking, a developer consists of four essential constituents, as follows:

(1) A "reducer"
(2) A preservative
(3) An accelerator
(4) A fog restrainer

The reducer is usually an organic chemical like Elon or Hydrochinon or Pyro. Without it, the solution would not develop the image. Being a reducer, it follows that it is useful in the developer only so long as its ability to take up oxygen is retained. It, therefore, follows that useless oxidation of the reducer by exposure of the developer to air should be guarded against.

It is the function of the preservative to keep the useless oxidation of the reducer to a minimum. For this work

[1] C. E. K. Mees—*Journal of the American Chemical Society*, November, 1913.

sodium sulphite is by far the most widely satisfactory chemical. If, however, only these two materials were put into a developer, the solution would take an infinitely long time to act. To accelerate this process it is necessary that the solution be alkaline. Sodium carbonate is quite satisfactory for this, and in addition is cheap and easy to secure.

But these three materials in one solution, while they would cause the development of those grains which were exposed, would, if allowed to act for the time necessary to develop the image, also cause the development of other grains which were not exposed. It is to check this tendency that the restrainer must be added. The function of this restrainer, which is usually potassium bromide, is to stop the development of fog, or those grains which are in such a state that the slightest action of the developing solution will start their reduction.

It is necessary, of course, in a solution designed for development, that the amounts of these constituents must be properly balanced in their relations to one another. There must be just sufficient quantity of reducer to perform the work necessary, sufficient sulphite to preserve this amount of reducing agent while not in use, a minimum of carbonate to make the reaction time normal and a minimum quantity of restrainer that will prevent a reduction of grains which have not been intentionally exposed.

After the reaction of development is complete the plate should be rinsed carefully before proceeding to the operation of fixing, in order to remove developer held in the gelatine. At this stage the plate still contains, in addition to to the developed silver image, the balance of the silver bromide which has been unaffected by exposure. Being opaque, it must be removed.

THE FIXING BATH

The fixing bath, too, is a combination of chemicals in solution which is somewhat analogous to the developer. The fundamental material entering into it is "Hypo" or

sodium thiosulphate—which, in solution, is a solvent for silver bromide. Unfortunately, in combination with developer which may be left after rinsing, it will cause the deposition of colloidal silver. This is the familiar "dichroic fog", which appears as a red stain by transmitted light and as a green one by reflected light. It is necessary, therefore, to add to the fixing bath a chemical which will counteract this possible action or "kill" the developer. Acetic acid has been found to perform this function quite satisfactorily.

In the fixing bath, as well as developer, it is also necessary to add sodium sulphate as a preservative, not only for the Hypo itself, to prevent its being acted upon by the other materials in this solution, but to prevent the oxidation of developer carried over into the fixing bath before it is "killed" by the acetic acid.

Finally, there is usually added a hardening agent which will tend to toughen the gelatine so it will stand a thorough washing in water of average temperature. This hardening agent is, in most cases, an alum. White potassium alum has been found most satisfactory.

DRYING

It should be remembered that the making of a photographic negative is not completed until the developed emulsion is dried, for unless this seemingly simple operation is correctly carried out the care in the previous operations may all be in vain.

During the drying of a photographic emulsion on glass or other solid support there is a gradual contraction of the gelatine vertically in the direction of the support until it is, when dry, scarcely one-twentieth of its wet thickness. This, of course, results in a series of strain adjustments, which must proceed at a uniform rate if the original image is not to be distorted. The drying of all negatives, therefore, should proceed at a uniform rate — in an atmosphere where there is no likelihood of contamination.

In all operations — exposure or formation of the latent image, development, fixation and drying — the routine methods should be standardized to preclude the introduction of disturbing factors.

The writer wishes to acknowledge his indebtedness to Mr. A. P. H. Trivelli for the interesting micrograph shown in Figure 4.

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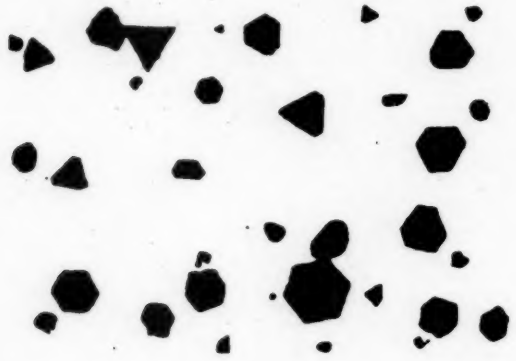

FIGURE 1

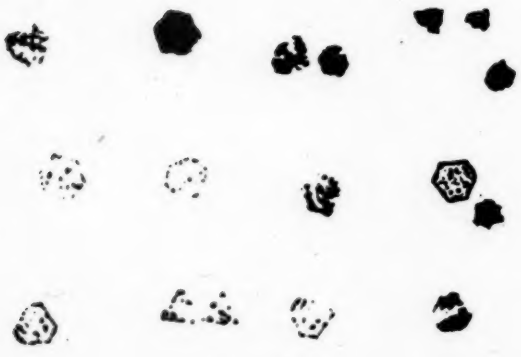

FIGURE 2

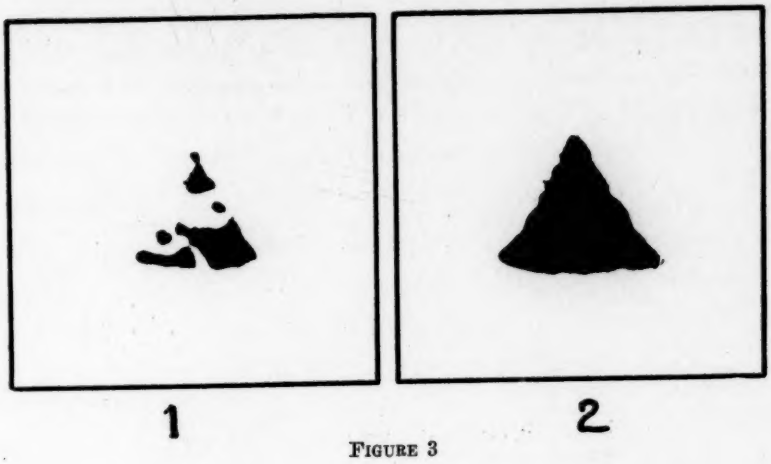

FIGURE 3

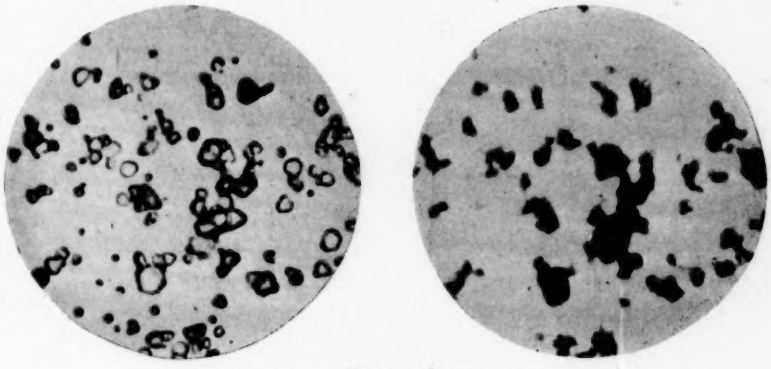

FIGURE 4

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ORGANIZATION

All societies with large membership rolls of wide geographic distribution must be managed by a council. This council may be composed of a definite group elected by the membershiy at large or it may be by executive officers and certain committees, who assume the management and thereby comprise the council. The progressive tendencies, the democratic spirit and the standards of professional dignity of an organization are for the most part dependent upon the character of those constituting this council.

If a council consists of but a few men, similarly situated and located, a membership of wide geographic distribution, the organization is handicapped. It is stifling the best purposes of an organization to continue to provide a small coterie of men, year after year to direct the policies of an organization regardless of the fact that their scentific and professional qualifications are unquestionably incontestable.

It is obvious that a time limit must close one's activity in a council of this character in order that his place may be filled with younger blood which carries enthusiasm as its main attribute.

Enthusiasm and energy are coupled inseparably with youth and are always found to diminish with the declining years past middle age. From the knowledge and experience gained during the ambitious periods of juniority comes the wisdom and dignity of seniority, and it is to this very necessary class that the managing body or council of any organization must look for wise counsel and conservatism.

The Western Roentgen Society, founded late in 1915 by Roentgenologists of the central United States, was given at its very birth these principles along with other features of successful organization. The governing body or council consists of the executive officers, elected in open meeting each year, a board of counselors, selected by the president,

to represent his policies in such states or districts as he may designate, and two standing committees. In each of the committees one member is retired each year. The vacancies in these committees are filled one by election and the other by the retiring president. It may be observed that the senior division of the council may be represented by these committees. The executive officers and board of counselors represent the active and more aggressive or junior division of the council. In this manner the derogatory influence of continuous centralized control is adverted and a full supply of new blood is constantly secured.

Under such a regime the rapidity in growth in this Society has been almost phenomenal. As it closes its fifth annual session it is undoubtedly the largest Radiological society in America if not in the world.

The growth in number of radiological societies in the United States within the past few years, seems remarkable. It is unquestionably an expression of a rapidly growing science. For some fifteen years, workers in this line were satisfied with but a single organization, but within the past five years or so many organizations have come into existence. The four natural divisions of the United States are at present supplied by four well organized societies, *i. e.* the Eastern, Central, Pacific Coast and Southern divisions. In addition to these more or less general societies there are many very well organized local societies. For example, the Philadelphia, Omaha, Kansas City, Chicago, and New York Roentgen Societies. Several state societies have organized a roentgen division within the past few years.

In the JOURNAL OF ROENTGENOLOGY attention has frequently been directed to the growing demands for one large radiological association, truly democratic and national in character, combining all the virtues made possible only by quantity as well as quality of membership, with a section in the American Mediical Association and a powerful influence generally to the glory of the medical profession.

Abstracts

HARRY WESSLER, M. D., and CHARLES M. GREEN, M. D. Intrathoracic Hodgkins Disease: Its Roentgen Diagnosis. *The Journal of the American Medical Association,* Vol. 74, No. 7, February 14, 1920.

Hodgkins disease at times presents clinical irregularities which make diagnosis difficult. To determine the value of radiographic examination in this disease, the authors investigated the chests of 25 cases of Hodgkins disease and described the following types: (1) The mediastinal tumor type. (2) The infiltrative type. (3) Isolated nodules or metastases in the lung. (4) Discrete nodes at the roots of the lungs.

Paratracheal nodes appear on the plate as an oval shadow situated to the right side of the trachea, in the upper mediastinum and below the sternal end of the clavicle. The frequency of involvement of these nodes in Hodgkin's disease and its rarity in other diseases may be of value in the diagnosis of obscure cases.

Among other conclusions the authors state that although the roentgenogram in some cases presents nothing characteristic, in a considerable number a distinction from other forms of new growth or glandular enlargement can be made. The article is adequately illustrated.

H. H. JAMWAY, M. D., New York City. Treatment of Cancer, Particularly of the Tongue, Tonsil and Rectum, by Buried Emanations. *The American Journal of Roentgenology,* February, 1920.

The direct application of radium to cancer has been used for a number of years in the Memorial Hospital. For the past year and a half it has been used only in selected cases.

A more perfect method is now in use, that of the use of radium emanations. These emanations are sealed in glass tubes and embedded within the tumor tissue.

The radium emanation is collected in a long capillary tube which is divided into minute parts by a flame, sealing the ends. These tubes are three mm. by one-fourth mm. These tubes are placed in hollow needles, no larger than an aspirating needle. Then by a wire stylet these tubes are placed evenly throughout the tumor mass.

The advantages of this method are:

1. There is very little loss of radiation, inasmuch as the emanation is inserted within the tumor tissue and left there either permanently or until it sloughs out and almost one hundred per cent of its efficiency is directed against the tumor.

2. It is economical as small quantities will produce results that other methods will only by large quantities.

3. Both the beta and gamma rays are used in them entirely, filters not being used. Thus the full effect is utilized.

4. A more intense radiation of the growth can be secured with greater safety and less discomfort to the patient because the surrounding tissue is not damaged.

5. The simplicity of the method makes it not only the easiest method but furnishes a means of treatment for tumors inaccessible to other means. For instance: Tonsils, Sinus and Rectum. These claims have been substantiated in practice and are illustrated by a variety of cases.

The method is not entirely devoid of danger. Two patients with suppurating growths died of sepsis, a number of hemorrhage. However, the chance of life is far greater than by any other method. The old and feeble are susceptible to sepsis. Hemorrhage when seen to be impending can be prevented by ligation. E. W. Rowe.

Henry K. Pancoast, M. D., Philadelphia. The Roentgen Ray in Cancer of the Uterus. *American Journal of Roentgenology,* 1920, Vol. VII, No. 3, pp. 146, 147.

In the treatment of all forms of malignancy by either, or both, radium and roentgen ray the primary growth must be carefully studied as well as the manner of metastasis and the places it is liable to occur. An inoperable malignant growth is easily excited to metastasis. Care must be taken not to stir up activity.

Uterine cancer should not be treated by roentgen ray alone. The roentgen ray should be used to supplement surgical or radium treatment. Cancer starting in the cervix should be treated with radium first. If metastasis has occurred the roentgen ray should be employed also.

The maximum dose of radium is generally employed. At the best its effects are exerted within a radius of only a few centimeters. The roentgen ray must be employed if it is necessary to go beyond these few centimeters.

Unless roentgen ray treatment is carried out scientifically it is worse than useless for it will cause cell proliferation in insufficient quantities. All paths and metastatic growths must be treated with sufficient dosage to cause death of the cancer cells.

To give lethal doses at increasing depths many portals of entrance must be used. The use of radium needles and emanation tubes around the periphery as well as radium in the cervix is yielding as good results as is possible. In the use of radium statistics are improving. E. W. Rowe.

M. William Clift, M. D. Fluoroscopic Examinations in Injuries of the Head. *The American Journal of Roentgenology,* 1920, Vol. VII, No. 3, pp. 136–142.

The experience of the war has demonstrated the value of fluoroscopic examination of the head for fractures, foreign bodies, and sinus infections.

Civil practice since the war has demonstrated the practical value. Fluoroscopy is an additional aid to roentgenographic methods, not a substitute. It may aid to secure a good position that differs from a standard position.

The army small radiator type of Coolidge tube gives clear

images. A spark gap of five inches, milliamperes three to five, and a properly prepared retina are the requisites.

Cranium: The head is placed in the dorsal position and rotated to a lateral in both directions while under observation.

Sinuses: The frontals and anterior ethmoids are examined in the anterior posterior position. The maxillary sinus in the Waters position.

Fluid (pus or blood) or foreign bodies are easily determined.

Jaw: In the dorsal prone position slight variations of the mandible give satisfactory views of the jaw.

Eye: The injured eyes are turned toward the screen until the silhouette of the lids are seen. The eye ball is watched during rotation, while the head is held still. This enables one to see if the foreign body is in the globe or outside.

Foreign Bodies: The following points may be determined:

1. Penetration of the skull. Extent and nature of the fracture.
2. Penetration of the dura as evidenced by the presence of fragments or foreign body.
3. The presence of a foreign body:
   a. Size.
   b. Location.
   c. Depth.

Foreign bodies in the brain pursue a fairly straight course. So that the principal ray passing through the foreign body and point of entrance will pass through the fistula or tract.

Operative Guides: For the jaw and neck the intermittent control method of Ledoux-Lebard is of great importance.

For a surgical guide the Hirtz compass is accurate and with experience rapid with the fluoroscopic technique. The electro-magnet used by the method of M. Henri Bécleré is of more value to the surgeon because extraction is preferable to mere localization. If these methods are combined, a

bronchoscope used in the place of the central rod, the forceps can be passed down with a minimum of trauma.

E. W. Rowe.

H. H. Hazen, M. D., and F. J. Eichenlaub, M. D. The Roentgen-Ray Treatment of Verruca Plantaris. *Journal of the American Medical Association,* 1920, p. 1311.

The literature gives a few instances of the use of the roentgen-ray in the treatment of this disease.

One of the authors is a professor of Dermatology and Syphilology in Georgetown University School of Medicine, and Howard University School of Medicine; and the other is an instructor in the same school, where they have had ample opportunity to watch their cases.

Records of sixteen private cases treated by roentgen ray are at hand. The technic is one and one-third Holzknecht unit every three to four weeks. All but one were cured. That one was particularly resistant, being the flat wart of known stubbornness to treatment.

There was one recurrence where a patient discontinued treatments. The number of treatments varied from one to seven. The average was three. The cases seem permanent. Some of the cases have been followed six years. All other forms of treatment for this disease have been abandoned.

E. W. Rowe.

E. H. Weld. The Toxicity of Pyellographic Media. Report of death following the use of Thorium Nitrite. *Journal of Urology,* 1919, Vol. III, p. 415.

Following the death of a patient after the use of thorium nitrite the author carried out a number of experiments to determine the relative degree of toxicity of sodium bromide, potassium iodide, and thorium nitrite.

A twenty-five per cent solution of sodium bromide, a twenty-five per cent solution of potassium iodide, and a fifteen per cent solution of thorium nitrite were injected into the veins of dogs. The sodium bromide even in quantities

of fifty-five c.c. caused no effect. Two or three c.c. of the potassium iodide solution caused death. Sodium iodide when given in quantities as high as fifty c.c. caused a moderate reaction from which the animal soon recovered. The thorium nitrite caused death in all but one dog and that was a fresher solution than the others.

Deductions:

1. The potassium radicle is dangerous. Potassium iodide should be used with great care.
2. Thorium nitrite is toxic to the heart muscle. The older the solution the more toxic it becomes.
3. Sodium bromide is non-toxic, cheap, easily prepared, readily accessible, not irritating, and the best media brought forward. It should be chemically pure and may be sterilized by boiling.

For pyellography a twenty per cent solution is sufficient. For cystography a ten per cent solution is sufficient.

E. W. Rowe.

C. Thurston Holland. War Lessons for Radiology. *The British Medical Journal,* March 13, 1920, pp. 253–255.

When the war broke out in 1914 the British had no roentgen equipment nor trained specialists in roentgenology. The army was devoid of a conception of the importance of the roentgen ray in war surgery. The permanent staff of officers failed to grasp the situation. The younger surgeons from civil practice knew the importance of such a department. The older men were hostile. Equipment that was available was inadequate and antiquated. Trained specialists called from busy practices to take up war work were detailed to minor positions, often they were given only orderly duties. Technicians were placed in the roentgen departments, often these were students with little or no training—few of them with any medical training. The surgeons made their own interpretations and controlled the situation everywhere. They openly were hostile to any recognition of expert roentgenologist and reported all was well

even when the service was deplorable and insufficient. The eminent surgeons meeting in the War Office had never had associated with them one expert on roentgen matters.

Later conditions changed. Experts were added to the different commands. Sir John Goodwin, Sir Berkeley Moynihan, Sir Harold Stiles and Sir Robert Stiles are especially to be thanked for their efforts to assist in developing the roentgen department. But the real organization of the department came too late to be of any material assistance.

In answer to the question, "What has been the effect on the production of *x*-ray apparatus, on the invention of new instruments?", he says that the only outstanding contribution has been the American Standard Mobile Unit and the radiator type of Coolidge tube. In the later months of the war these units and supplies were turned out in fairly adequate numbers. English-made equipment, especially tubes, has not been as serviceable as some foreign makes. (American?)

"What has been the effect of the war on *x*-ray workers and *x*-ray works?"

Those experienced in the roentgen work have been taught very little by the war. Localization was highly developed and bone injuries were more carefully studied. Diaphragmatic hernias were frequently recognized and made recognizable by the roentgen ray. Gas gangrene was early recognized. Tropical abscesses were frequently seen. In therapeutic work the treatment of keloids by radium and roentgen ray has been advanced.

The great effects of the war on x-ray work: Roentgenology was brought into prominence. Enormous numbers of laymen were educated to its use. The whole medical profession were impressed with its use. The older men and those in general practice knew little of its use in disease of the thorax, kidneys and gastro-intestines. A large number of men have learned well to use and coöperate with the roentgenologists.

Dangers:

A large number of males and females have a smattering of roentgen knowledge. These technicians may be a menace to good work.

All thinking of following roentgenology as a specialty should take a special college course even if they have had war experience.

E. W. Rowe.